Public Comments
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My comments are based on reading the NIST progress reports through June 2004. This is a tedious task, since much information and analyses have been compiled. However, the information is far from complete as many results and details are not included in these progress reports. Therefore, it is difficult to gain a comprehensive understanding of the NIST results thus far. Moreover, the lack of sharp conclusions on the NIST objectives, and their bases in the NIST analyses and fact-finding, makes it difficult to assess the rationality of the NIST many efforts. For those efforts, it is apparent that many individuals have done a lot. It would appear the building and fire groups of NIST have engaged in a significant, collective study for the first time, and this in itself should have benefit. However, the investigative conclusions need to have focus, clarity and impact. To that end, I have questions and comments.

A hallmark for a successful investigation is to establish an analysis that is consistent with the known facts, fills in the gaps with sound data and calculations, and has not overlooked anything of significance. According to the NIST No. 1 objective, it must establish answers for "why and how the WTC 1 and WTC 2 collapsed following the initial impact of the aircraft". The important factors are (1) the fire temperatures and its duration, (2) the collapse mechanism based on the aircraft damage and the heating by the fire. Let me comment on these:

1. Fire temperature and duration

(1) The importance of knowing the temperature achieved by the steel on the fire floors is crucial to establishing the cause of the buildings collapse. A common

forensic technique for determining the temperature reached by steel in a fire is to microscopically examine the grain size. Why has NIST not used this method?

(2) NIST has chosen to simulate the fire by computations using FDS. This is an ambitious effort and Kevin McGrattan and others should be commended, but with a study of this magnitude it would have been valuable to conduct experiments for actual WTC floors or significant sections. A quarter of a floor could have been tested for fire and the heating of the structure. It would only involve a plan space at 100 x 100 feet. This could have settled many issues. Especially when it is realized that no experimental results exist for compartments with the height to plan dimensions of the WTC floors.

(3) It is well known that the FDS code depends on grid size, it is still in its development for predicting combustion and its temperatures. Since it is essential to input into the structural analysis a temperature-time curve, I would urge NIST to use alternative computations of fully developed fire temperatures in addition to solely FDS results. Such methods are available in the literature. Boeing would not take the use of CFD models in its aircraft design lightly, and neither should those assessing fire behavior, especially from NIST.

(4) The FDS simulation is based on a workstation fuel load established by "personnel from a company that supplied office furnishings to the occupants of WTC 1. Information on the distribution of papers and other office items was provided by a frequent visitor to these offices". This fuel load is about 4 psf, and is at the lightest end for offices. It may be why the FDS simulation leads to fires burning only 1 hour on a floor, and at average temperatures of 600 C. This result appears inconsistent with the facts, as WTC 1 burned for 103 minutes at collapse, and 600 C is a critical temperature usually taken for steel to fail. Hence, it would appear that this simulation would never cause the steel structure to fail by fire alone.

2.Catastrophic Structural Failure

(1) On Impact computations: NIST says if the engine does not impact a floor slab, the majority of the engine core will remain intact through the exterior wall penetration. The residual velocity and mass of the engine is sufficient to fail a core column in a direct impact. An engine is nearly the dimension of the floor height, so how could the engine not be impeded by first impacting a floor. This would suggest very limited core column damage is possible. Why is NIST then considering in its "working hypothesis" that considerable core damage is likely? We all realize that it is very important to determine an accurate estimate of the core column damage. What is the accuracy of such impact calculations? It is known that landing gear and at least one engine was found in the surrounding streets suggesting a flight path through the building. Can NIST use information on the location of the engines to assess the likelihood of core column damage? Are their computations consistent with the engine flight paths?

(2) Single truss analysis: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C causing the truss to act as a catenary. Other independent work done by Usmani et al, and Burgess et al., show similar results and indicate that the truss deflections occur at temperatures ranging from roughly 400 to 600 C. The truss deflections can cause failure to its connections, or cause the external columns to become unstable. It would seem that temperature is a key factor in causing failure. How does NIST relate its work to those cited above in the literature? If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Is this be a mode of global collapse? NIST considers the number of floors to be removed before the columns would become unstable, but would not the loss of 2 or 3-floors cause the failure before this instability? Is a critical temperature a good measure of structural failure as it might appear from the single element computations, and the implication of the loss in strength at elevated temperatures?

(3) E 119 tests: Standard fire tests were conducted at UL. Two were done at a 35 ft span representing the short span in the WTC towers. These had ¾ in. thickness of insulation applied. A third test was conducted with public viewing with ½ in. insulation, and at a span of 17 ft. In that test the truss was scaled–down so that it was half its depth. The failure criterion was primarily structural integrity for the most part. Will NIST be analyzing these results to see how they would apply to the WTC? If the temperatures reached by the steel in these tests was sufficient to cause failures in the WTC single element or multi-frame computations, but the structure did not fall in the E 119 test, will NIST reconcile these differences? The scaled the depth of the truss to ½ full-scale that NIST in its 17 ft E 119 test does not consider heating. The scaling was done for stress purposes, but the heat transfer along the web into the concrete deck is now changed, and greater cooling of the web will occur. Since a critical temperature is a criterion for failure in fire resistance testing, the temperature of particularly the full-scale 35 ft. truss should be carefully examined. Moreover, as UL G805 appears to be the justification of the upgraded 1.5-inch insulation thickness, why would the recent tests give such different results than the UL G805 listing? Also UL N826 might have been a more appropriate listing for the WTC, and it gives 2 1/16 inches. So what is the meaning of the E 119 test and how should it be used in this WTC analysis?

(4) Insulations history: NIST has traced documents and recommendations related to the thickness of insulation, particularly on the floor joist assembly. They have found and stated the following:

a. The truss specified thickness was 0.5 in., but as applied was 0.6 +/- 0.3 inch.

b. The upgraded truss insulation was 1.5 inches (based on UL G805, May 2003, p. 78), but was later measured in application as 1.7 +/- 0.4 inches based on photographic analysis, but was reported in audit documents over 1997 to 1999 as 2.5 +/0.6 inches, with thickness as high as 4 inches (June 2004, Vol. 4, I 15-18).

c. A model code recommended 2 inches for 2 hours in a 2001 assessment of a similar truss (June 2004).

d. A report by Burro-Happold recommended in 2001 that the upgraded insulation could be dropped to 0.5 inches based on an ambient value of the conductivity used in a calculation, but settled on a recommendation of 1.3 inches. (May 2003, p. 82)

As seen by the various E 119 results for the Cafco insulation, and the varied specifications and recommendations on the WTC truss insulation, it is incumbent on NIST to give some rationality to these variations. Since the amount of insulation is so crucial to the outcome of finding the cause of failure, NIST needs to be very sure about how much insulation was actually in place. The latest information from PANYNJ indicates that the upgrade in WTC 1 could have been as much as 4 inches over the 1.5 inch specification. Yet this upgrade occurred when field workers were having difficulties in application, and that was the main reason for the Burro-Happold study. A 4-inch radius on a 1 inch steel rod would give a 9-inch diameter cylinder – a very big result. How much confidence does NIST have on these large amounts? Do they have photographic evidence as in the previous smaller amounts? Would not a hearing on the insulation thickness and related issues serve NIST well in documenting the facts and rationality of these variations? If so much variation occurred for the WTC, how does this relate to the protection in other buildings?

It appears that NIST has to answer some very focused questions with clarity and accuracy.

1. How many core columns were removed by impact and why?
2. How much insulation was in place during the fire?
3. What are the critical temperatures needed for failure?
4. Could the fire cause these temperatures?

The global collapse mechanism of the buildings must be made as clear as possible. A vague answer expressed by the current NIST working hypothesis is not sufficient. NIST has expended a lot of good individual effort, and it has done some very good fact finding and analyses. Now all of that has to be put together, and it seems contractors (who we have not heard from) play a significant role. NIST needs to harness those individual efforts and expertise in a balanced evaluation. Reliance solely on complex computer models should not be the sole basis of the answers. If the core of the answers are really revealed and understood, NIST should be able to explain them in simple fundamental physics, and not shroud them in computer graphics. This was the purpose of the investigation, and this conclusion on the cause of the collapse must be made with sharp clarity.